Director of
Central
Intelligence

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Prospects for Soviet Military Technology and R&D

National Intelligence Estimate
Volume I—The Estimate

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SCOPE NOTE

This National Intelligence Estimate was prepared in response to a request from the Under Secretary of Defense, Research and Engineering, for an assessment of Soviet prospects for military technology and R&D and of the relative US and Soviet standings in key military technologies. The Estimate addresses:

- The status and prospects of key Soviet technologies for the 1980s.
- The ability of Soviet military research and development to meet future military requirements.
- The resources allocated to R&D for the 1980s.
- Projected new military systems in significant mission areas for the 1990s.

The Estimate does not describe systems that will reach operational status in the 1980s and form part of the total Soviet military capabilities for the 1990s. Soviet requirements and programs for the deployment of military forces, as well as projected Soviet military capabilities for the 1980s, are described in other NIEs. The findings of those NIEs have been taken into account in our projections of Soviet systems for the 1990s. The projections do not deal with the effectiveness of the individual systems or with the contributions they will make to overall Soviet military capabilities.

Sixteen technology areas have been identified as key to Soviet military weapons development and are addressed in this Estimate. Some important areas, such as electronic warfare and command and control, are not addressed, although communications for command and control systems are discussed. When we have not been able to see a direct connection between basic research and development of a key technology we have not related that research to projected future systems.

Comparisons with US technology are used to provide benchmarks for the description of Soviet capabilities in key technologies and to show relative technological standings. Technology is only one input to military effectiveness, and no conclusion should be drawn from the

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comparisons of technology in this Estimate as to comparative military capabilities. The relative status of US-Soviet technology is consistent with that used in the fiscal year 1981 posture statement of the Under Secretary of Defense, Research and Engineering.

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PREFACE

The level of technology achieved in a country is important, but is not the sole determinant of its military capability. The philosophy of weapons design, the balance achieved between performance and quantity, and the availability of technology in the field at the time needed are often more important than the level of technology incorporated in a system. Hence a comparison of the status of military technology in the USSR and the United States should not be presumed to indicate relative military capabilities, either present or future. The development and appropriate use of technology will, however, affect performance, producibility, cost, reliability, and maintainability of military systems. Also, in some instances the incorporation of new technology may be essential to meeting military requirements.

The 16 key technology categories chosen for treatment in this Estimate are broad, and many of the categories are interdependent. Microelectronic advances, for example, will have direct impact on computers, signal processing, and electro-optic sensors; advances in all key technology areas involve production technology to some degree.

One approach used to describe the progress of Soviet technology is to relate progress in technology to new systems requirements and projected performance. A second approach used is to provide analogous US achievements as a benchmark for comparison. Future prospects for relative US-Soviet standings in technology are based on simple extrapolations of past trends, modified by projected Soviet advances. There are inherent uncertainties in both approaches which may prove to be significant.

Projections of Soviet weapon systems of the 1990s are based on evidence of early R&D programs and on known or estimated Soviet system performance trends and also the availability of relevant key technologies, along with judgments of where in their R&D cycle the Soviets freeze the incorporation of available technology into systems design. We often do not have direct evidence, however, of Soviet plans for the incorporation of available technology that new performance may require. Further, the eventual outcome of a program in early R&D may not be clear even to the Soviets.

KEY JUDGMENTS

The fundamental motivation for Soviet military research and development is to support the achievement of a military capability that competes with and surpasses that of the United States and its allies.

The Soviets have established a military R&D program that is large, growing, and of high priority. In 1979, it probably accounted for almost one-fourth of Soviet defense expenditures—or almost 3 percent of gross national product—and one-half of Soviet expenditures for all R&D. Other key inputs to military R&D as well—such as the level of scientific and technical manpower and capacity at dedicated facilities—show steady long-term growth. Although economic growth is slowing, trends in the level of activity in weapon system R&D programs indicate that the resources devoted to R&D will continue to expand through 1985 at least as fast as total defense spending, which is projected to grow at 4 to 5 percent a year.

There is an alternative view [1] that military R&D cannot be isolated from Soviet work in pure science and civil R&D to the extent that it is in this Estimate. According to this view, work in these fields is relevant to motivation and goals, as well as to the resources that can be brought to bear on scientific and technological problems the Soviets would like to solve. The resources that are described in the Estimate should be described in more precise terms in spite of the problems involved with Soviet figures.

The Soviets have made and are expected to continue to make good progress in developing the technologies that we believe are key to their future military capabilities. The prospects and a few potential applications of these key military technologies are summarized in table 1. The Soviets' progress is a result of extensive development efforts as well as continued success in acquiring technology from abroad. The Soviets have traditionally given high priority and devoted large amounts of resources to the acquisition and exploitation of information and hardware from the West.

Acquisitions of foreign technology by legal, illegal, and clandestine means have had significant impact on the Soviets' capability in the key technologies, especially in microelectronics and computers. We expect them to continue to devote a major effort to this process in the 1980s.

[1] *The holder of this view is the Director, Bureau of Intelligence and Research, Department of State.*

Table 1

Key Soviet Military Technologies: Prospects and Projected Applications

Key Technology	Prospects for the 1980s	Soviet Applications Projected for the 1990s
Computers	Increasing speed, memory size; software problems	Advanced command, control, and communications for theater and strategic air defense
Microelectronics	Large-scale integration by the early 1980s; production difficulties	Long-range air-to-air missile; ground attack aircraft
Signal processing	Strength in theory and optical processing; hardware limitations	Towed arrays for antisubmarine warfare; improved avionics for air superiority aircraft
Production technology	Shortages in precision machinery, automated manufacturing; gradual modernization	Enhanced neutron warheads; improved air superiority aircraft
Communications	Increased frequency range and bandwidth, emphasis on reliability and security	Advanced strategic and theater systems for command, control, and communications
Directed energy	Multimegawatt high-energy laser, improved pointing and tracking accuracy	Improved ground-based air defense laser; space-based laser antisatellite system
Guidance/navigation	Improved correlation techniques and conventional accelerometers and gyros	New weapon system for Typhoon ballistic missile submarine; solid-propellant ICBM
Power sources	Continued multifaceted R&D, including nuclear and magnetohydrodynamic sources	Ground- and space-based lasers; global nava communications
Structural materials	Good in large structure fabrication; increased use of composites	T-80 tank follow-on; large space shuttle
Propulsion	Strength in rocket and nuclear propulsion; difficulties in large rocket engines; advances in solid propellants	Large space shuttle; new class of attack submarine
Nuclear weapons	Good capability; emphasis on enhanced radiation and transplutonics	Enhanced neutron warhead artillery rounds
Chemical explosives	Excellent capability; advanced work in hydrogen-free inorganic explosives	Improved self-propelled artillery
Acoustic sensors (antisubmarine warfare)	Limitations in towed arrays; new low-frequency sound sources	Active, low-frequency sonar; long-range towed arrays
Nonacoustic sensors (antisubmarine warfare)	Continued R&D on optical, infrared, and radar detection	Air- and space-based submarine wake detectors *
Radar	Continuing strength in over-the-horizon, real-aperture, and millimeter-wave systems	New surface-to-air missile; improved Moscow ABM system
Electro-optical sensors	Good progress in line and matrix arrays; adaptive optics control	Advanced multipurpose space station; improved helicopter gunship

* Feasibility uncertain

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The current US-Soviet relative status and trends in the key technologies are shown in table 2. Significant Soviet advances are expected in most technologies and the Soviets probably will improve their overall relative standing through the 1980s. We do not expect these changes in relative standings to be dramatic, however. In the four technologies that we consider to have especially broad impact—production technology, computers, microelectronics, and signal processing—we do not expect the Soviets to reduce their lag. Fundamental changes would have to take place in their centrally directed management techniques and their technological base for rapid advances to be made in these four technologies. Such fundamental changes are unlikely.

There is an alternative view [2] that, in addition to significant advances by the Soviets and improvement in their overall relative standing in key technologies, they are likely to improve their relative position in the four broad impact technologies as well. This view is based on the fact that, in these four technology areas, the Soviets have achieved steady progress relative to the United States over the past 10 years, on an assessment that present trends are toward narrowing the gap, and on projections of future Soviet military policy that is expected to call for an increase in high-technology systems. It further holds that, in areas which the Soviets consider important to their military goals, Soviet advances—both absolute and relative—are likely to occur.

The Soviet military R&D management system is characterized by continuity in funding and personnel, strong centralized authority, and the direct involvement of top leaders to assure responsiveness of the defense bureaucracy. It is most effective for conducting high-priority programs such as major aerospace and armor systems R&D. The R&D management approach is not well suited, however, for administering programs of secondary priority—especially those involving many organizations and cutting across many bureaucratic lines—or for programs requiring successful coordination of diverse and interactive technical disciplines, such as those involved in microelectronics. Despite impending leadership changes in the USSR, we foresee no fundamental change in its R&D management system over the next decade.

Soviet strategy in military R&D involves two major themes. The principal theme has been the controlled introduction of evolutionary advances in technology to fulfill evolving military requirements. This theme has sometimes made innovative use of technology, often of technology inferior to that of the West. It avoids excessive demands on either the production or technology base and provides weapons that can be maintained and used by troops possessing moderate technical

[2] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; and the Director of Intelligence, Headquarters, Marine Corps.*

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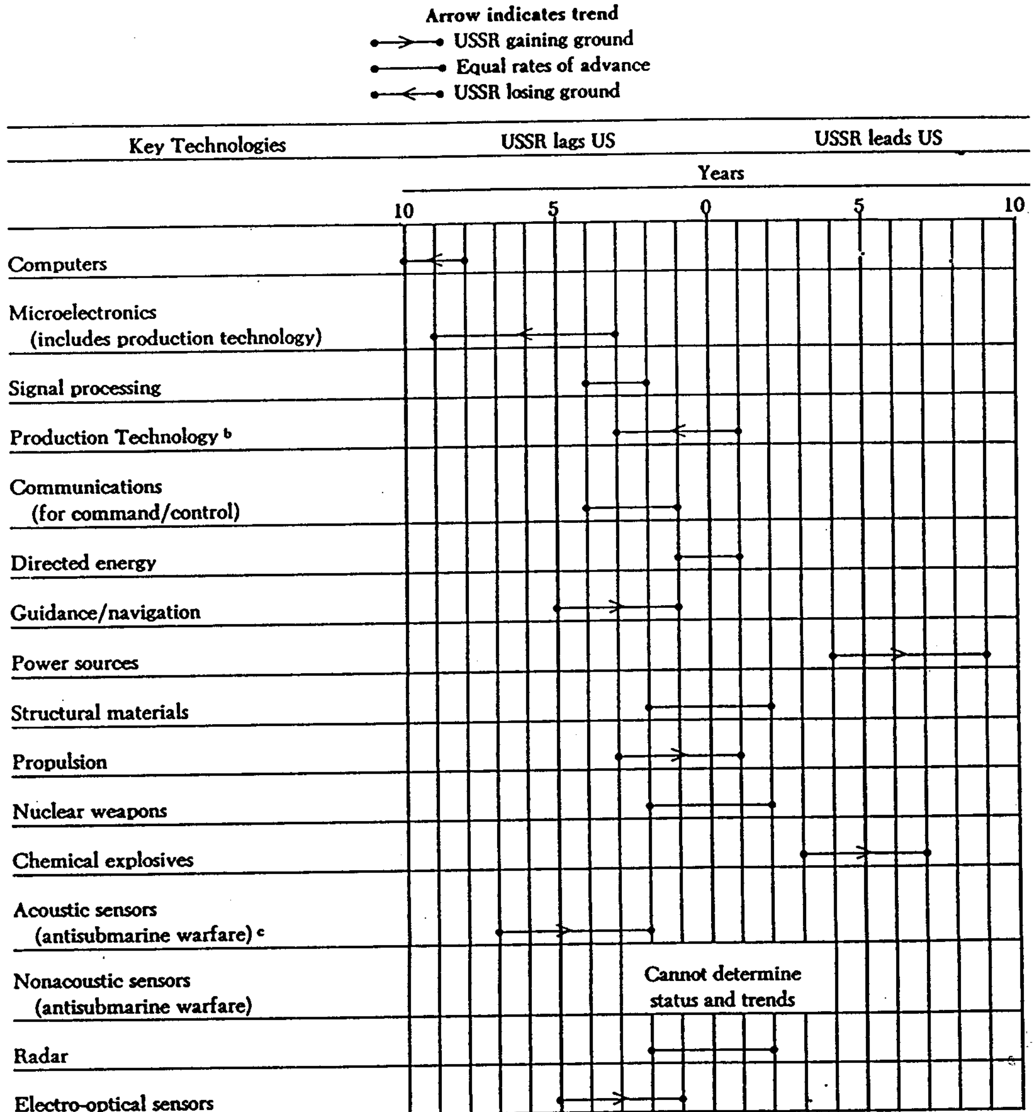
Table 2

Relative US-Soviet Current Status and Trends in Key Military Technologies [a]



[a] *Following is an alternative view of the Director, Defense Intelligence Agency, with respect to the comparisons made in this table: Sound judgments of the relative levels of militarily meaningful technology cannot be conveyed in such a simplified table. Although the Intelligence Community is not well equipped to render US-Soviet comparisons, if such comparisons are to be included in this NIE, they should, as a minimum, include comparisons of applied as well as basic technology to provide the reader a better perspective on Soviet military technology and on the results of the Soviet approach to military technology and R&D. A table illustrating this more comprehensive approach is provided by the holder of this view as table 2A. Table 2A represents a comparative analysis prepared by the Defense Intelligence Agency using all available intelligence resources and taking into account similar contract work performed for the Under Secretary of Defense, Research and Engineering (USDR&E). Support for the judgments in table 2A is provided in the Estimate text.*

[b] There is uncertainty concerning trends in this technology.

[c] *The Director, Bureau of Intelligence and Research, Department of State, believes that, in fact, Soviet acoustic ASW technology will lag further and further behind US technology in this area.*

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Table 2A

Key US-Soviet Technology Comparisons
Current Status and Trends

LEGEND:
B: Basic technology (laboratory proven)
A: Available-for-use technology (includes foreign acquisitions)
T: Tested technology (at test ranges)
D: Deployed technology
X: Notable exceptions to general assessment

TREND:
→ Relative shift in favor of USSR
← Relative shift in favor of US
···· Equal rates of advance or inability to assess

Key Technology	US Lead 10 — 5 — Years 0 — 5 — Soviet Lead 10	Trend	Years To Close Gap (US) or USSR	Comments/Exceptions
Computers	B X1 A T D X2	← → →	10+ 10+ 10+ —	US domestic applications are driving factor. Soviet acquisitions from West/Japan can limit US lead in some areas to two to four years. X1: Hybrid computer technology. X2: Computers for battlefield management.
Microelectronics (includes production technology)	B A T B	← ···· → ····	10+ 10+ 10+ —	US domestic applications are driving factor. Soviet acquisitions from West/Japan can limit US lead in some areas to two to four years.
Signal processing	B A T D	···· → ···· ····	1 3 (0-3) 4-5	Both countries have good theoretical signal-processing capability. Soviets lag in ability to fabricate some small-size–large-capacity signal processing equipment. Soviets lead in pulse doppler processing currently in test and about to achieve IOC (initial operational capability).
Production technology	B A T D	→ → ···· ····	10+ 10+	Soviets deficient in automated production processing; lag the US in numerically controlled machine tool technology. Soviets generally effective in fabrication of heavy structures.
Communications (microwave, satellite)	B X1 A X1 T D X2	→ → ···· ····	5-6 4-6 3-6 1-6	Strong US commercial emphasis on microwave and satellite communications. X1: Soviets have basic technology for satellite-to-satellite communication; no known use; difficult to monitor. X2: Strong Soviet emphasis on survivability through hardening, mobility, and the use of multiple, redundant communications.
Communications (high frequency)	B A T D X1	···· → → →	— — (4-6) (4-6)	Strong Soviet emphasis on HF (high-frequency) communications. X1: Strong Soviet commitment to buried antennas, survivable communications.
Directed-energy weapons (DEW)	B X1 X2 A T X1 X1	···· → → ····	— (3-6) (3-6) —	Serious unknowns due to USSR's secrecy on DEW; most is known about its laser programs. Large Soviet commitment to high-power devices. Greater Soviet commitment of resources. X1: Soviet lead in high-power tubes and large antennas. Soviets making gains. X2: Research/development relevant to particle beam weapons.
Guidance/navigation	B T D X1 X2 X3	···· → →	— 2-3 2-3	Both countries understand basic technology. US leads in general in miniature computer-electronics components. X1: Recent Soviet ICBM accuracies are equivalent to US. X2: Soviets have deployed second-generation stellar-aided inertial system on SLBMs. X3: Soviets have deployed mobile IRBM; tested mobile ICBM.
Power sources	X1 B X1 A X1 X2 T X1 D	→ → → →	(5-7) (5) (5) (5-10)	Strong Soviet commitment of resources for directed-energy weapons; US reduction of effort. X1: Superconducting magnets, gas turbines: better US manufacturing and low-temperature technology. X2: Rotating electronic generators.

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Table 2A (Continued)

Key US-Soviet Technology Comparisons
Current Status and Trends

Key Technology	US Lead 10–5	Years 5–0	Years 0–5	Soviet Lead 5–10	Trend	Years To Close Gap (US) or USSR	Comments/Exceptions
Structural materials (armor and metallic)		B A T D	X2	X1	---- ---- ---- ----	— — —	Soviets have copied many Western alloys; they have shown some originality but remain dependent on Western research accomplishments. Soviets catching up with US in fracture mechanics, powder metallurgy, and casting of superalloys. Soviets have apparently developed effective tank armor based on steel and ceramic compositions. X1: Large Soviet commitment to thick plate welding. X2: Soviets hold many basic patents in electroslag casting.
Structural materials (nonmetallic)	D	B A T			---- ---- ---- ----	— 5-7 5-7 5-10	Synthetic polymeric materials: Soviets possess good theoretical knowledge; research follows West; adequate in conventional polymers but deficient in high-performances polymers. Ceramics: good technology, some innovation noted; adequate production. Advance composites: Broad research effort under way; design and production experience lag US.
Propulsion (nonnuclear)	X1 X1 X4 X1 X4 X1 X4	B A T D	X3 X6 X5 X6 X2	X6 X5	---- ---- ---- ----	— — — —	X1: Cruise missile engine; turbofans. (Soviets are starting to catch up.) X2: Transonic compressors. (US is closing the gap.) X3: Scramjet/ramjet supersonic combustion, scramjet thermal protection system, ramjet ejector. X4: Solid rocket. (Soviets are rapidly closing the gap.) X5: Liquid rocket. (US would need six to eight years to close the gap.) X6: Hybrid rocket. (US would need eight or nine years to close the gap.)
Propulsion (nuclear)		X1 B A T D			---- ---- ----	— — — —	Soviets have new devices in test. Soviets emphasize high-power-density propulsion plants. X1: Long-core-life propulsion plants.
Nuclear weapons		B	A T	D	---- ---- ---- ----	5 (5) (5) (10)	Both countries enjoy requisite sophistication in weapons design. Soviets have capability to achieve sophisticated design techniques/methods when necessary. Differences in sophistication due to basic design philosophy, not technology level.
Chemical explosives		X1	B A X2 X3		→ → → →	(5) (5) — —	Soviets emphasize newer materials. X1: HMX production technology. X2: Fuel-air explosives. X3: Nitrocellulose coated aluminum particle antiradiation warheads.
Acoustic sensors (antisubmarine warfare)		B A T D			---- ---- ---- ----	5 — 5 5	Soviets are probably developing military towed arrays. Soviets emphasize active rather than passive sonar. Soviet sonar development represents evolutionary improvement.
Nonacoustic sensors (antisubmarine warfare)		Unknown			---- ---- ---- ----	— — — —	Large Soviet program characterized by diversity of technique and by an apparent decision to use multisensor devices.
Radar		B A T	X1 X2 X3 D X1 X4		---- → → →	— — — (3)	X1: Over-the-horizon radar (US would need five years to close gap). X2: High-power millimeter-wave technology (US would need five years to close gap). X3: Low-altitude air defense radar. X4: ABM radar.
Electro-optical sensors		B A T D			← ← ← ----	3 3 3 2	US excels in fabrication technology.

[redacted]

skills. The resulting weapon systems often have had a limited range of applications; however, the Soviet approach is to field multiple systems, which cover the spectrum of desired performance. This theme has resulted in the fielding of large quantities of weapons, and the subsequent introduction of incremental modifications to improve their performance, benefiting from field experience, evolving technology, or changing threat perceptions.

The secondary theme in Soviet R&D has been a willingness to accept the higher risk and costs required to develop new types of weapons based on advanced technological concepts. This theme emphasizes designs that are critically dependent on the development of new technology or the successful use of unproven technology. This approach was apparent in the development of the USSR's first ICBM and nuclear weapons, in the Soviets' more recent construction of titanium hull submarines, and in their recent developments in laser weapons and armor. Despite their long-term commitment to this R&D approach, however, the Soviets still have critical requirements, such as in strategic defense, for which neither the USSR nor the United States has found advanced technological solutions.

The features of Soviet R&D strategy are not expected to change radically in the future. Most new Soviet systems will probably be based on evolutionary improvements in the types of systems now in service. The Soviet R&D process has been largely successful over the last several decades and has acquired considerable momentum. Also, steady advances in key military technology in the 1980s will probably provide for significant new performances, which we project for the 1990s. We expect the Soviets to take full advantage of the opportunities for new evolutionary performance that their maturing technology makes available.

We expect the Soviets to place increased emphasis on advanced technological solutions in their R&D. They have applied this approach when advanced technology was needed to satisfy a critical requirement that the evolutionary approach could not meet; when the growth potential of a family of systems had been exhausted; and when, for either case, technology had matured enough to make new approaches technically feasible. As their technology advances, we believe the Soviets will see increasing promise in and may be able to determine the feasibility of advanced technological solutions for longstanding requirements. There will probably also be increased activity devoted to advancing the technological state of the art and to developing a broader range of technical options. For initial development of new concepts the Soviets may create—as they have in the past—ad hoc R&D management structures outside the existing R&D organizations responsible for evolutionary R&D.

There is an alternate view that the existing Soviet R&D establishment is both more functional at internally developing new technologies and more resistant to reorganization than the above judgment suggests.[3]

We expect the numbers of new or modified Soviet systems reaching operational status into the 1990s to remain near historical levels, some 200 in each of the past several decades. Some of the new Soviet systems will incorporate the advanced technological theme. A selection of systems projected in significant mission areas for the 1990s is shown in table 3.

The chances of technological surprise—the unexpected appearance of militarily important advances in technology—will probably increase significantly through the remainder of the century. Soviet technology advances will make more R&D options available to the USSR, and the guideposts of US experience probably will become even less useful to the Intelligence Community as an aid in understanding future Soviet activity.

[3] *The holder of this view is the Director, Bureau of Intelligence and Research, Department of State.*

Table 3
Selected Soviet Systems Projected for IOC in the 1990s

System/Concept	Potential New Performance	Key Technology [a]
	Projected High Probability of Occurrence	
Improved air superiority aircraft	Advanced lookdown/shootdown; possibly control configured	Materials, guidance, computers, microelectronics
New weapon system for Typhoon ballistic missile submarine [b]	Accuracy (CEP) of 500-600 meters	Computers, guidance/navigation, materials
Modernized theater command, control, and communication systems (widespread deployment)	Versatile survivable equipment, automated control system	Microelectronics computers, production communication
New class of attack submarine	High speed, great depth, quietness	Production, materials, propulsion
T-80 tank follow-on [b]	Improved day/night, cross-country mobility; armor protection	Sensors, materials
Advanced space station (permanently manned) [b]	Permanently manned, multimission	Sensors, signal processing
	Projected Medium Probability of Occurrence	
Space-based laser antisatellite system	Multiple target capability	Directed energy, power sources
Improved Moscow ABM system	Reentry vehicle discrimination, improved target-handling capability	Computers, signal processing
	Projected Low Probability of Occurrence	
Enhanced neutron warheads (for artillery rounds)	Broad-area antitank weapon (limited collateral damage)	Production
Air- and space-based submarine wake detectors (feasibility has not been established for these concepts)	Broad-area search (if concept feasible)	Signal processing, sensors

[a] Key technology available for systems development.
[b] May reach initial operational capability in the late 1980s.

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DISCUSSION

I. THE SOVIET MILITARY R&D PROCESS

A. The Soviet Organization for Military R&D

1. The military has top priority in the competition for Soviet research and development resources. This priority and the extensive management controls applied to military R&D, including establishing realistic performance requirements and delivery schedules, have been instrumental in mobilizing resources to supply the military with a steady stream of new weapons. During each of the decades of the 1960s and 1970s, the Soviets brought more than 200 new or modified weapon systems to operational status.

2. Over this period the Soviets have built a sizable and growing permanent military R&D establishment concentrated in the nine defense industrial ministries. Five of these ministries have large design bureaus that serve as the general contractors for developing missiles, aircraft, ships, radar, and armored vehicles. The other four ministries supply such components and subsystems as nuclear weapons, conventional ammunition, communications equipment, and critical radioelectronic components and instrumentation. Collectively the defense industrial ministries are provided with the best facilities, can attract the most qualified personnel, and are assured of continuing financial and material support.

3. The military consumer and defense industrial producers have close relations with the leadership. The party and the Defense Council—chaired by the party general secretary—follow major weapon development and rely on an extremely powerful management organ—the Military-Industrial Commission (VPK)—for continuous oversight. The VPK oversees the entire development process—ranging from coordination and documentation of weapons (R&D requirements) through assurance that production schedules are being met. Substantive inputs to the Defense Council are provided by officials from the Ministry of Defense, the General Staff, the Soviet military services, and top officials from the defense industry. The military establishes weapon requirements and directly influences and monitors R&D by posting highly qualified representatives in weapon design and production facilities. As a consequence of its priority and high-level oversight, the defense industrial sector has been largely insulated from the difficulties affecting the Soviet economy. The network of organizations managing and performing military R&D is depicted in figure 1.

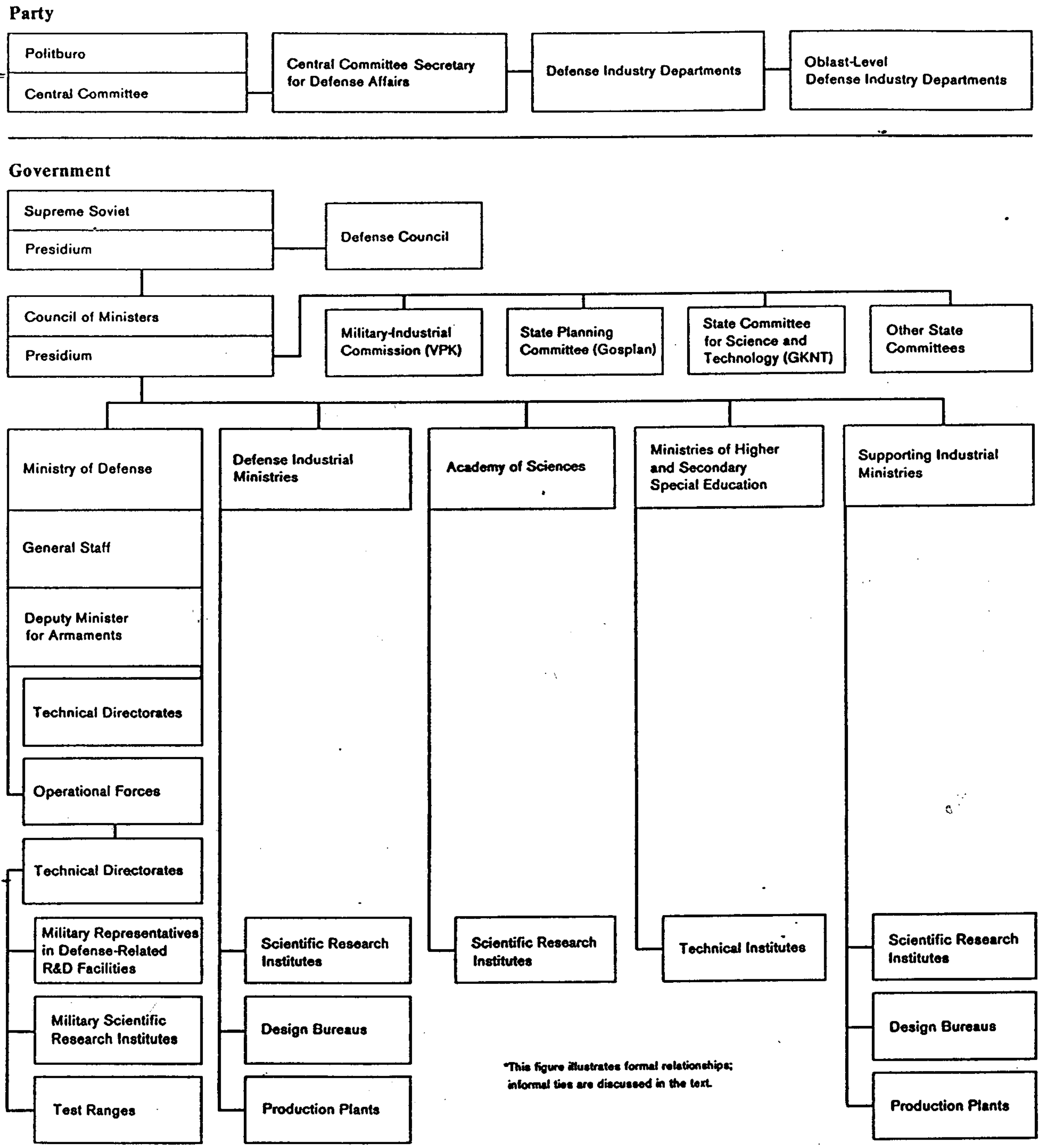
4. The military also relies on the civilian Academy of Sciences and educational research establishment for advancing basic science and on civilian industry for R&D and the production of certain materials, components, and subsystems. The State Committee for Science and Technology (GKNT) coordinates overall Soviet science policy, manages large civilian R&D programs, and manages Soviet foreign technology acquisition efforts. The military influences the direction of basic research by concluding contracts with the Academy of Sciences and Ministry of Higher and Specialized Secondary Education, and by working through the leadership to affect the allocation of state budget funds for basic research. Military control of civilian industrial participants in a weapon program—application of VPK directives and stationing of military representatives—is the same as for defense industrial participants.

5. The Soviet system is defense dominated and the military sector, substantially insulated from most of the organizational and resource constraints of the civilian economy, is able to outperform significantly the nonmilitary sector. The Soviets maintain a captive, continuously operating military R&D and production capability, which, though not independent of civilian industry, is less subject to the economic and bureaucratic impediments that hamper the nondefense sector in a centrally planned economy. In contrast to that of the United States, the Soviet approach neither must rely on nor is able to derive substantial support from a strong civilian R&D base which advances the state of the art on its own initiative.

6. There is an alternate view [4] that the preceding paragraph overstates the difference between the performance of the military and the civilian sectors

[4] *The holder of this view is the Director, Central Intelligence Agency.*

Figure 1
R&D-Related Organizations in the Soviet Party and Government Structure*



*This figure illustrates formal relationships; informal ties are discussed in the text.

of the Soviet economy, and the extent to which the military sector is insulated from the problems of the economy as a whole. Defense production depends to a large extent on civilian sectors of the economy such as chemicals and metallurgy. Moreover, a large portion of the weapons design and production activity is governed by the same rules and incentives as civilian production. These, in turn, produce economic and bureaucratic impediments which are only partly overcome by the periodic intervention of the Soviet leadership in defense matters and by the deference accorded military production by the operating planners and managers.

7. Soviet civilian R&D and elements of the Academy and educational establishment experience certain deficiences in manpower and material resources. Moreover, the complex plan, supply, finance, and incentive regulations that govern civilian R&D management have not been effective in orienting the R&D establishment to the needs of the consumer.

8. Diversion of R&D resources to the military slows the rate of purely civilian technical advance and, in turn, affects productivity in the civilian sector. In the 1980s Soviet economic growth will be increasingly dependent on improving productivity, but there is little evidence for a future slowing in the growth of military-related R&D. Indeed, the increasing sophistication of Soviet weapons means that the military will further pursue basic science and use a growing variety of materials and components developed in civilian industry.

B. Weapon Design Philosophy and Plan and Program Management

9. Over the last three decades the Soviets have pursued two basic themes in weapon design. Their first strategy calls for evolutionary upgrading of weapon quality through the gradual introduction of new technology. In line with this strategy, they have developed weapon design practices that stress commonality of components, reliability in the field, and adequacy in mission performance. This policy has yielded weapons capable of being produced and deployed in large numbers at acceptable cost, in a timely fashion, and at reduced risk. This policy has reduced the demands on the technology and manufacturing bases, but may contribute to long periods between achievements in the laboratory and availability to the weapon designer. This strategy is expected to remain dominant.

10. The secondary theme in Soviet R&D has been a willingness to accept the higher risk and costs required to develop new types of weapons based on advanced technological concepts. The Soviets probably will place increased emphasis on this theme. In the past such designs were pursued when the evolutionary approach was deemed inadequate to meet changing threats or doctrinal requirements, when the growth potential of a family of systems had been exhausted, or when a concentrated R&D effort created new technological opportunities. The Soviets have achieved a technology level where they are expected to be more willing to pursue advanced technological approaches which entail greater risk than the evolutionary approach but which hold greater promise of meeting their performance objectives. Where entirely new weapon concepts are involved, falling outside existing design bureau capabilities, the Soviets may form—as they have in the past—ad hoc organizations for proof of feasibility, but this will be followed by application of more traditional administrative mechanisms.

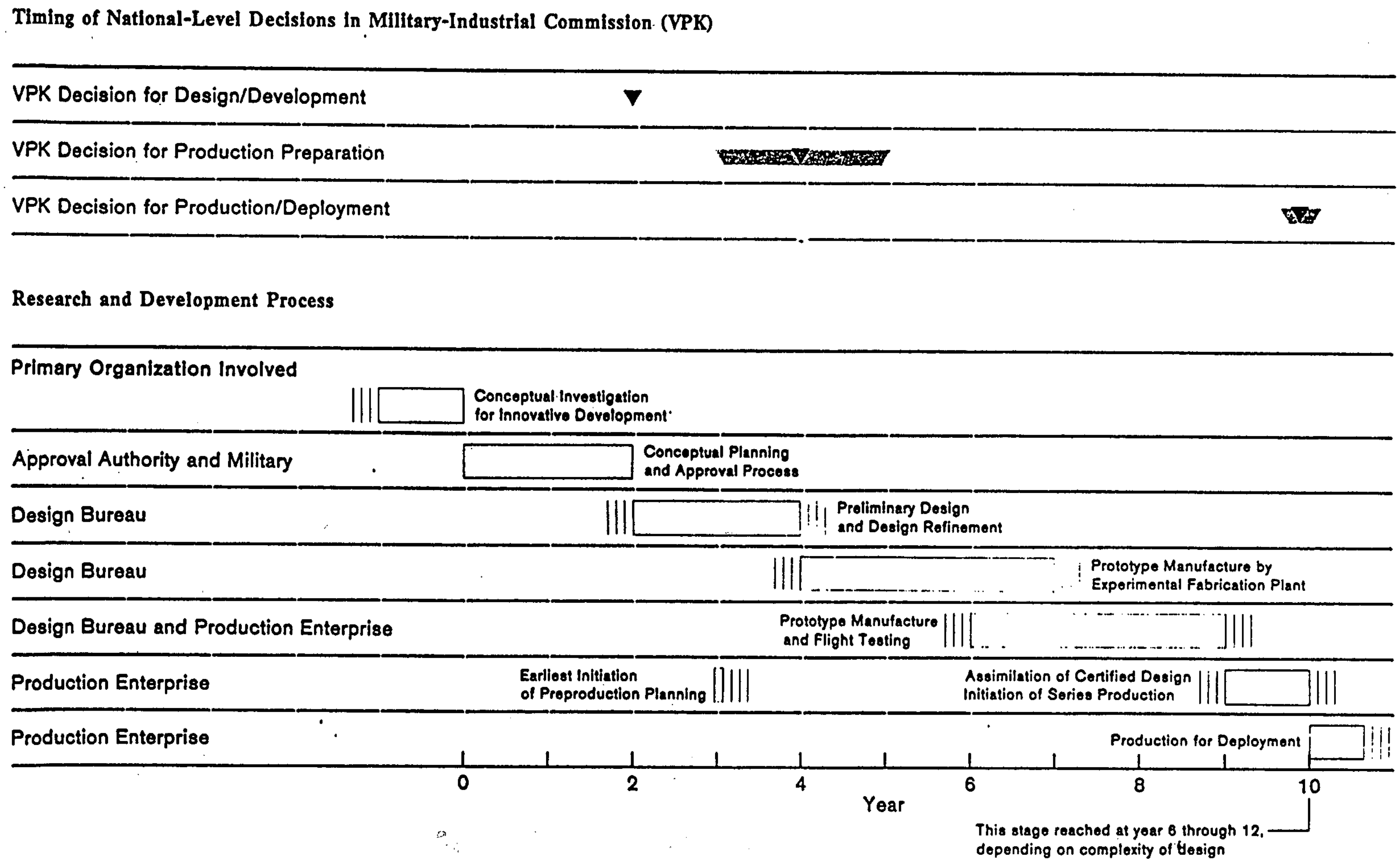
11. Soviet five-year plans and the more elaborate annual plans are used to manage R&D and production activity. The plans are formulated at at least three levels—national, ministry, and R&D and production facilities—with assignments becoming more detailed as they are transmitted to lower levels. The Soviets now are concluding the preparation of the 11th Five-Year Plan, covering the 1981-85 period. By now the Soviet leadership probably has established the major guidelines for defense and defense industrial development through 1985, and thus will have begun the process of formulating specific plan assignments for industry. Although there is an aversion to major changes, plan targets can be and are modified frequently after they have been established.

12. Major weapons development programs normally take six to 12 years from initiation to initial operational capability (IOC), depending on the complexity of the weapon system. A series of VPK decisions is used to manage the program (see figure 2):

—The first specifies assignments for draft design, technical design, and prototype manufacture, as well as the testing, preparation, and manufacture of new types of materials and production machinery.

—The second identifies series production plants (both system and components), sets production levels, and continues development work

Figure 2
Chronology of Soviet R&D Decision Points and Design Activities



through pilot model production (full-scale engineering development).

—The third, made after the prototype is subjected to a lengthy series of test and validation procedures, specifies numbers and types of weapons to be deployed.

These weapon acquisition stages reflect the Soviets' preference for incorporating proven technology and incremental advances in their weapon systems. The Soviets apparently make a commitment to single concepts and designs early in the process. The initial requirement outlines a single concept and calls for single or multiple designs.

13. The first VPK decision represents a national commitment, although the resources necessary to implement the program are not authorized until the complete design is formalized and received. The second VPK decision—authorizing production preparation and assimilation—reflects the frequent separation in the USSR between design and experimental organizations and those performing series production. The third VPK decision authorizes series production and deployment.

C. Critical Aspects of Soviet R&D Organization and Management

14. The assignment of clear priorities, strong centralized management, and organizational stability and continuity in military R&D facilitate the prosecution of high-priority weapon programs. These same features often can hinder performance in other areas. Table 4 summarizes features of Soviet R&D management and presents some of the resulting implications of this R&D approach.

15. The Soviet military R&D management system has been highly successful in managing high-priority military programs such as the development of major aerospace systems and armored vehicles. Programs can be authorized rapidly and funds committed for extended periods of time. Long-term personal contacts between leadership elements such as members of the Politburo and Defense Council and primary weapons

Table 4

Implications of the Typical Soviet Military R&D Management Style

Characteristic	Observations	Implications
Stability and Continuity	Continuity in funding, management, and design teams	Greater efficiency in some programs
	Long-term, close relationships between leadership and weapons developers	Promotes entrenchment, secrecy, and striving for self-sufficiency among people and organizations
		Resistance to change, unorthodox approaches
Strong Centralized Management	Formal program plans and techniques	Can overcome resistance to change in selected programs
	Provides managers with simple decision criteria	Acquisition process is responsive to top management
		Major weapon programs are effectively controlled
		Large number of programs that underpin overall military R&D not adequately controlled
High Priority for Military R&D	Military assured sufficient quantity of high-quality resources	Production goals are usually achieved on schedule
	High-level attention	Reduces resources available to civil sector
		Factor contributing to lag in economic growth and overall technological progress

[redacted]

developers permit close monitoring of R&D program performance and rapid program response. The combination of formal plan and program techniques and informal measures enables Soviet leaders to make clear assignments of priority to large projects. This allows managers at all levels to apply simple decision rules on resource allocation questions. In high-priority areas the Soviets encourage and enforce program fulfillment by maintaining centrally administered reserves to meet unforeseen developments, and by creating special financial and professional incentives and special authorizations for acquiring supplies.

16. This management system is generally not well adapted, however, for administering programs of secondary priority, those involving many organizations, or those which cut across bureaucratic lines. The high priority accorded major programs means that remaining projects may be deprived of essential resources. The ability of high-level management to scrutinize only a limited number of programs means that projects of secondary import must rely on inefficient bureaucratic distribution mechanisms to acquire resources—often of inferior quality. Soviet organizational insularity, secrecy, and tendency to strive for self-sufficiency lead to major difficulties when the cooperation of many organizations is required on complex programs in other than major weapons areas. Moreover, the common institutional separation of research, design/development, and production establishments fosters redundancy of effort and retards the rapid assimilation of new technology. Finally, although Soviet five-year plans and long-term programs are sources of program continuity and stability, they also restrict flexibility and create aversion to major change.

17. The management controls applied to high priority weapon programs overcome many of the problems endemic to Soviet centralized planning and management. Areas requiring continuing incremental advance in a number of mutually supportive technologies, however, suffer under the Soviet management approach. For example, in spite of qualified personnel and massive infusion of resources, the Soviets continue to lag the West in design and production of microelectronics components.

18. There is an alternate view[5] that the discussion in the two previous paragraphs and table 4 may be misleading in that the management deficiencies identified therein apply primarily to low-priority civilian R&D programs rather than to military programs. All military programs—not just those of the very highest priority—enjoy a special status in the planning, resource allocation, and management process, and are accorded favored treatment, which helps to insulate these projects from most of the organizational and management problems that plague the civilian sector. As a result, while competition for resources also exists in the military sector, even military programs of lesser importance are favored over civilian programs in the competition for scarce resources. For example, military projects are accorded special treatment by the national supply organizations. Military supply requests are filled first and requesters with military contracts are assigned the most reliable and best equipped supply firms. This helps to insulate military projects, including those of secondary importance, from the chronic supply shortages that trouble the less favored components of the economy. The high-level commitment to defense also serves to ameliorate much of the organizational insularity and problems involved in coordinating military programs of all priorities that cross organizational lines. And, finally, the powerful position of the Ministry of Defense as customer helps to blunt many of the incentive problems that are a major source of inefficiency in the civilian economy. Quality control is a case in point; the in-place and powerful military representative teams effectively ensure that products, even those of secondary importance, are delivered on time and meet the military's quality specifications.

D. Prospects for Change in the 1980s

19. The fundamental character of military R&D organization and management is not expected to change over the next decade. Major weapon program management already is highly effective, but, elsewhere, gradual and cautious tinkering with the administrative mechanism likely will continue. The party probably will attempt to institute measures that will allow it to exercise greater high-level direct control of the economy.

20. Grappling with the critical problem of relatively slow movement of new technology from the laboratory into production will mean continued industrial reorganization merging R&D and production establishments; further stress on direct contracting; tying R&D bonuses and other perquisites to the effectiveness of new technology in production; and improved

[5] *The holders of this view are the Director, Defense Intelligence Agency, and the Director of Intelligence, Headquarters, Marine Corps.*

dissemination of technical information. Acquisition of foreign technology to compensate for domestic technical deficiencies will continue as a major program and yield considerable benefit, but hard currency shortages and other factors may require greater self-reliance on the part of the Soviets.

21. Although difficult to predict, we believe a post-Brezhnev leadership would not institute a markedly different approach to R&D planning and management. This view is based on the apparent absence of significant R&D policy disagreement in the current collective leadership and on the entrenched position of the large R&D bureaucracy. Nevertheless, past leadership transitions have resulted in some abrupt and extreme shifts in the administrative mechanism. The impact on military R&D can be especially pronounced because of the extensive interest and involvement of top leadership elements.

22. We believe that economic problems will not substantially threaten the position of the military in resource allocation or lead to major change in the administrative mechanism. The military, the VPK, and the defense industrial ministries are in a strong position to defend their interests against any fundamental changes would pose a challenge to their entrenched power.

II. MILITARY R&D RESOURCES

A. Past Trends

23. Since 1965 spending for military R&D in constant 1970 rubles is estimated to have accounted for about half of all Soviet R&D expenditures. Military R&D has taken on the average about one-fifth of Soviet spending for defense, and about 2 to 3 percent of Soviet gross national product (GNP). Military R&D expenditures have grown more rapidly than Soviet spending for civilian R&D, have been the most rapidly growing category of Soviet defense spending, and have outpaced overall Soviet economic growth. Thus, while defense spending has accounted for a roughly constant 11 to 12 percent of Soviet GNP[6] since 1965, military R&D has consumed an increasing share of Soviet defense spending. In 1979 military R&D expenditures probably accounted for almost one-fourth of Soviet defense expenditures and almost 3 percent of GNP.

24. To compare the size and growth of US and Soviet military R&D activities, we have estimated what the Soviet activities would cost in constant 1978 dollars if they were carried out in the United States. In 1968, US outlays for military R&D were approximately one-third larger than the estimated dollar cost of Soviet military R&D activities. Thereafter, US outlays declined in real terms until 1976, when they began a moderate increase. The estimated dollar cost of Soviet military R&D activities, in contrast, increased steadily. In 1978 the estimated dollar cost of Soviet military R&D was almost 85 percent greater than US military R&D outlays. These figures, however, do not measure the comparative effectiveness of US and Soviet military R&D spending and should not by themselves be interpreted as indicators of relative Soviet and US accomplishments. We are not able to make a similar comparison of the dollar cost of Soviet and US civil R&D activities, although we recognize that some of these activities may affect military R&D, particularly in the United States.

25. Our estimates of Soviet military R&D expenditures are based on highly aggregated Soviet statistics and only a small number of intelligence reports. They are subject to considerable uncertainty but are, however, consistent with our physical evidence of Soviet military R&D activities and we believe them to be indicative of the magnitude and trend of Soviet military spending.

26. An examination of the resource inputs to military R&D programs shows that the Soviets have steadily increased the resource base committed to military R&D. We believe that this approach, in conjunction with an analysis of the outputs of the R&D process, best portrays trends in the level of weapon system R&D activities, identifies shifts in Soviet military R&D priorities, and reveals the strength of the Soviet commitment to military R&D.

27. Total Soviet manpower employed in civil and military R&D has been growing at more than 4 percent a year; employment in those organizations conducting military R&D has probably grown even faster. In the mid-1970s the Soviets probably employed at least 1.5 million people in military R&D or about half of the manpower working on R&D in the USSR. More than 80 percent of these worked in facilities subordinate to defense industrial ministries.

28. There has been a steady increase in floorspace at many of the major Soviet defense R&D establishments. In Soviet aerospace R&D, for example, floorspace has increased at an average annual rate of about 5 percent since 1965. For the Ministries of Avi-

[6] This estimate reflects the definition of defense spending used in the United States.

ation Industry and General Machine Building most of the major research facilities have been identified and measured. In these ministries, from 1963 to 1978, floorspace grew at average annual rates of about 4 and 6 percent, respectively. In other areas, a sample of 10 major Ministry of Shipbuilding Industry research and development facilities shows an average annual rate of growth of about 3 percent during the same period. Soviet nuclear weapon R&D floorspace grew at an average annual rate of about 4 percent between 1965 and 1977. In general, floorspace seems to be growing fastest in facilities developing advanced systems dependent on electronic subsystems, such as missiles, and in emerging technologies, such as lasers, where the basic R&D structure is still being established.

29. The Soviets appear to have supplied their R&D establishment with adequate facilities and manpower, but their work has been handicapped by a general shortage of equipment resources, especially in the area of high-quality technologically advanced precision instruments. Shortages exist despite the priority accorded facilities engaged in military-related R&D. The scarcity of Soviet-made equipment stems from production deficiencies, and has led the Soviets to rely on Western suppliers for many types of equipment. For priority projects the Soviets allocate hard currency for the purchase of Western equipment, but there is fierce competition for such funding and the process is time consuming.

30. Systemic pressures have affected resource allocations as well. Soviet R&D philosophy, procedures, and general level of technology have played a part in the steady expansion of resources devoted to military R&D. The Soviet evolutionary style of development relies on a series of incremental steps to achieve desired military capabilities; it favors military systems designed for single missions, requiring a large number of product lines to cover the mission spectrum. This R&D style requires that design teams and supporting workers be continuously employed turning out a steady stream of improved systems.

31. Analysis of the principal output of the military R&D establishment—the number and type of new or modified weapons designed for the forces—can be employed as an indicator of level of effort. Although the time required to develop or modify weapons varies considerably, the rate at which new and modified systems have reached IOC has shown remarkable stability. During each five-year period since 1960, the Soviets have completed development of some 110 to 120 systems. The increasing complexity and improved performance of Soviet weapons have required increasing allocations of resources to maintain the constant number of systems developed by the R&D establishment.

32. Data on Soviet expenditures for R&D are not available on a program-by-program basis. Some general appreciation of the relative shares allocated to key weapon system categories can be gained, however, by comparing the complexity, the amount of innovation, and the development time of each weapon system program. Aircraft and offensive missile programs have accounted for about half of the total military R&D effort since 1960. Defensive missile R&D programs have absorbed about 10 percent of the total, although their share was somewhat higher during the late 1960s. Submarine programs and ship programs have each taken about 10 percent of the total, but we believe the share devoted to surface ship efforts is rising slightly. Development of space launch vehicles and spacecraft for military applications has accounted for roughly 10 to 15 percent of the total. Evidence on ground forces R&D is sparse, but, judging by the flow of new weapons into the forces, we estimate that these programs have absorbed about 5 percent of the overall effort.

B. Prospects for the 1980s

33. We believe that resource allocations to military R&D will continue to grow in the 1980s as a result of the strong commitment made by the Soviets to a vigorous military R&D effort. Primarily because of demographic trends, Soviet overall scientific manpower will grow less rapidly than the 4-to-5-percent rate of the past. Difficulties facing the Soviet economy will precipitate a review of all major resource allocation decisions, including those relating to defense. The resource requirements of defense in general, and R&D in particular, however, will almost certainly retain their favored position, although at an increasingly greater cost to the Soviet system as a whole.

34. Attempts to remedy the military problems which we believe are of greatest concern to the Soviets—those involved in correcting deficiencies in their low-altitude air defense and submarine detection capabilities, for example—will require costly, high-technology approaches. Both continual upgrading of current weapons and the development of new systems will be required. Large numbers of new defense programs along with subsequent modifications to the

[redacted]

resulting systems will be the focus of Soviet military R&D activity for the rest of the century.

35. We have identified more than 50 new or modified aircraft, missile, ship, tank, and military space systems in test or sea trials. We have also identified about 50 additional programs in the pretest or pretrial stage. Beyond these systems, we believe there are a great many more planned for the 1980s. In addition to the 100 or so systems already identified, we know that many modifications to existing systems scheduled for completion in the 1980s are not yet under way. During the 1960s and 1970s, the Soviets brought more than 200 weapon systems to operational status in each decade. Thus, we project that the number of weapons developed in the 1980s probably will be about the same as in earlier decades.

III. KEY SOVIET TECHNOLOGIES

36. A Soviet technology is considered key if it is basic to a number of significant military functions or concepts; or if it is a pacing factor for a specific military capability. For example, among the Soviet military systems projected for the 1990s, computer technology is basic to new performance in strategic and tactical systems for command, control, and communications; in a follow-on to the Typhoon ballistic missile submarine (SSBN/SLBM) system; and in an air superiority fighter (including control configuration). The development of high-bypass-ratio turbofan engines in the propulsion technology area is the pacing factor in our projection of new Soviet performance capability in large transport aircraft.

37. Four of the 16 key technologies—computers, microelectronics, signal processing, and production—have especially broad impact. For example, microelectronics will probably play a major role in advances in computers and signal processing. Production technology is a significant factor in Soviet microelectronics, signal processing, guidance and navigation, and some areas of propulsion development, and, to a large extent, determines Soviet capability to move new technology from R&D into military applications.

A. The Soviet Technology Balance

38. The present status of the key Soviet technologies, relative to comparable US achievements, and future trends based on extrapolation of past trends in relative US-Soviet technology standings are illustrated in table 2 (included with the Key Judgments). The Soviets generally lag the West in those areas where excellence depends on the interaction of many diverse technical disciplines. In these lagging key technologies, Soviet centrally directed management techniques have apparently not met with much success. There is an alternative view [7] that the reasons for the Soviet lag in certain areas should not be generalized, as in this paragraph. Many other reasons are equally likely. For example, some areas of US lead may be attributable to US civilian consumer sector impetus for advancement in those areas. Many highly complex and successful Soviet programs have required interdisciplinary interaction.

39. The Soviets lead or are roughly equal to the West in certain areas of technology where large size is a feasible alternative to complexity. These are areas to which their single-purpose, high-priority, high-level management techniques are probably well adapted.

40. The Soviets' R&D practice of separating the research and design functions has made it difficult for them to orient research programs toward meeting their general technology development needs. It has, moreover, inhibited their development of refined product and process designs that may become key parts of production/manufacturing and basic technology capability. This R&D practice, however, has not inhibited their ability to do major weapons R&D, because they have designated a design bureau as the lead, or integrating, contractor with control over R&D and test facilities.

41. The development and integration of a broad technology base is probably significantly hampered by this R&D management approach. Examples include precision machining, basic to weapons guidance component technology, and photolithography, which is basic to microelectronics production technology. In an attempt to overcome these deficiencies the Soviets have created an organizational structure—exemplified by the Zelenograd Science Center for microelectronics development—which places both research and design as well as production functions inside one formal management boundary.

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[7] *The holders of this view are the Director, Defense Intelligence Agency; the Director of Naval Intelligence, Department of the Navy; the Assistant Chief of Staff, Intelligence, Department of the Air Force; and the Director of Intelligence, Headquarters, Marine Corps.*

42. The Soviets' progress in key technologies may also be slowed in part by their weapon design philosophy, which emphasizes solving a military problem or meeting a requirement with existing means rather than developing and applying new concepts made available by advancing technology. The Soviets prefer to meet military requirements through the use of proven technology. Hence, Soviet weapons R&D is much more requirements "pull" than technology "push"; this does not encourage broad technological development but generally results in timely and adequate fielded technology.

43. Significant Soviet advances are expected in most technologies and the Soviets probably will improve their overall relative standing through the 1980s. We do not expect these changes in relative standings to be dramatic, however. In the four technologies that we consider to have especially broad impact—production technology, computers, microelectronics, and signal processing—we do not expect the Soviets to reduce their lag. Fundamental changes would have to take place in their centrally directed management techniques and their technological base for rapid advances to be made in these four technologies. Such fundamental changes are unlikely.

44. There is an alternative view[*] that, in addition to significant advances by the Soviets and improvement in their overall relative standing in key technologies, they are likely to improve their relative position in the four broad impact technologies as well. This view is based on the fact that, in these four technology areas, the Soviets have achieved steady progress relative to the United States over the past 10 years, on an assessment that present trends are toward narrowing the gap, and on projections of future Soviet military policy that is expected to call for an increase in high-technology systems. It further holds that, in areas which the Soviets consider important to their military goals, Soviet advances—both absolute and relative—are likely to occur.

45. Soviet capability in the key technologies through the 1980s probably will be adequate, however, to support the requirements for new performance of 1990s military systems of the evolutionary type such as ICBMs, armor, and aircraft. Where new 1990s performance requirements call for the development of advanced technological concepts, certain key technologies will have special significance. Foreseeable advances in Soviet signal processing, along with projected developments in microelectronics and minicomputers, for example, have high future potential. These advances are expected to further encourage the Soviets' consideration of advanced technological approaches to solving longstanding requirements—for example, in antisubmarine warfare (ASW).

B. Soviet Acquisition of Western Technology

46. A basic component in the advancement of the Soviet technical base is the acquisition and exploitation of both information and hardware from the West. Through the selective acquisition of Western technology, the Soviets have realized three basic objectives:

- First, the reduction of risk by following or copying proven Western designs.
- Second, reduction of R&D time and costs by the use of Western designs and technology, including production technology and equipment.
- Third, incorporation of countermeasures early in the Soviet weapons development process through the clandestine acquisition of Western military-related technology during its R&D cycle.

47. The fact that the Soviets have traditionally given high priority and devoted large amounts of resources to the acquisition of Western technology using all means at their disposal indicates that such technology is of great value to them, although we cannot directly measure its impact. The efforts include *legal* importation through open trade channels and through student, scientific, and technological exchanges and conferences; *illegal* trade channels that evade export controls; and *clandestine* acquisition through recruited agents, industrial espionage, and communications intercepts. Legal acquisitions generally have their greatest impact on the broad technological base, and thus affect military technology on a relatively long-term basis. Acquisitions through illegal trade channels frequently have both civilian and military applications and thus are important in the near term. The clandestine acquisitions frequently have immediate value to the military. Table 5 summarizes the most important known Soviet successes.

48. Among the many sources of Western technology accessible to the Soviets, the most significant acquisi-

[*] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; and the Director of Intelligence, Headquarters, Marine Corps.*

Table 5

Acquisitions From the West in the Key Areas of Soviet Military Technology

Key Technology Area	Notable Successes
Computers	Illegal and legal trade acquisitions of complete systems, hardware and software, and clandestine acquisition of proprietary information; exploitation of captured avionics and fire control systems. A wide variety of Western minicomputers have been used in military systems.
Microelectronics	Complete industrial processes and semiconductor manufacturing equipment through legal and illegal trade channels.
Signal processing	Illegal trade acquisition of seismic streamers and associated computers and of acoustic spectrum analyzers.
Communications	Illegal trade acquisition of low-power, low-noise, high-sensitivity receivers.
Production	Legal and illegal acquisitions of automated and precision manufacturing equipment for electronics, materials, and possibly optical and laser weapons components; clandestine acquisition of documentation on production technology of weapons, ammunition, aircraft parts, turbine blades, computers, and electronic components.
Directed energy	Metal foils and optical components acquired through legal and illegal channels.
Guidance and navigation	Legal and illegal trade acquisitions of Omega and Loran navigation receivers; illegal and clandestine acquisitions of advanced inertial guidance components, including miniature and laser gyros; captured US equipment including terrain-following radars, antiradiation missiles, and fire control systems; clandestine acquisitions of air-to-air and surface-to-air missiles, ASW cruise missile and tactical ballistic missile guidance subsystems; legal acquisition of precision machinery for ball bearing production.
Power sources	Superconducting energy storage systems and associated cryogenic equipment through legal trade.
Structural materials	Legal purchases and intelligence acquisitions of Western titanium alloys and welding equipment.
Propulsion	Missile case filament winding technology through legal and illegal trade; some ground propulsion technology through illegal and legal trade (diesels, turbines, and rotaries); submarine nuclear propulsion plant designs by clandestine means; legal and illegal purchases of advanced jet engine fabrication technology and jet engine design information through clandestine means; captured jet engines from Vietnam.
Nuclear weapons	Design of various bombs and warheads (plus neutron bomb designs) and RV-related data through clandestine means;
Chemical explosives	Clandestine acquisition of manufacturing details of advanced high explosives for nuclear weapons.
Acoustic sensors (ASW)	Clandestine acquisition of underwater navigation and direction finding equipment; seismic streamers acquired through illegal trade diversion.
Nonacoustic sensors (ASW)	None known.
Radar	Exploitation of captured terrain-following radar and airborne intercept radar; clandestine acquisition of air defense radars and antenna designs for US SAM systems.
Electro-optic sensors	Clandestine acquisition of information on US reconnaissance satellite technology; illegal trade acquisitions of laser rangefinders for tanks.

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[redacted]

tions that directly impact on Soviet weapons development have resulted from clandestine collection and illegal trade diversions. The Soviets also have profited greatly from the exploitation of captured Western military equipment (such as that from Vietnam). Acquisitions having direct military impact have been in the form of weapon designs, manufacturing plans and drawings, components, subsystems, and in some cases complete weapon systems.

49. The Soviets and their Warsaw Pact allies also have had measurable success—mainly via *illegal trade* means—in acquiring controlled dual-use and defense-related production technology. The *detected* diversions and evasions over the last several years are heavily concentrated in the field of semiconductor manufacturing equipment and account for some 80 percent of the identified cases. The heavy concentration of semiconductor equipment acquisitions is believed to indicate Soviet efforts to improve the whole electronic components industrial sector. The controlled technologies being acquired by the Soviets and the Warsaw Pact are a revealing indication of their defense needs, which include, among other things, microprocessor designs and production technology, computer systems and parts manufacturing equipment, and a wide variety of laboratory and precision manufacturing equipment.

50. *Legal purchases* of Western equipment play a major role in modernizing the Soviet industrial base. Between 1970 and 1976, the Soviets purchased some $20 billion of Western equipment and machinery. These purchases included a number of categories having potential defense application—advanced materials and fabrication equipment, modern electronic componentry, laboratory and industrial test equipment, and automated production equipment and technology. Such purchases, requiring hard currency, are closely controlled by the State Scientific and Technical Committee (GKNT). Those meeting the direct or partial needs of Soviet industry for defense purposes are given the highest priority. The Soviets have also profited from other legal sources—especially from open literature and overt collection.

51. The *clandestine* and *illegal* collection activities are driven, first, by the needs of the military and the defense industrial ministries and, second, by the needs of the civilian sectors of Soviet industry that support defense production. The overall Soviet *clandestine* and *illegal* intelligence efforts are worldwide, centrally directed, and very selective. They are closely coordinated with overt acquisition, and legitimate purchases, particularly those efforts under the auspices of the GKNT. The USSR's efforts in these acquisitions are extensively supported by the other members of the Warsaw Pact.

52. The GKNT also initiates and manages the complex network of international scientific and technical agreements that the USSR maintains with the advanced industrial nations of the world. The S&T agreements are judged to provide valuable scientific information and technology for the USSR. The Soviets believe that under these agreements their scientists are able to acquire Western technology in such a manner that its S&T and military benefit are greatly enhanced.

53. Acquisition of Western technology does support and broaden the overall Soviet technology base and, in many cases, provides Western technology in manufactured form that can be utilized directly in Soviet components and systems. Once the Western technologies are acquired, however, their full exploitation and utilization become subject to many of the same technical and industrial limitations affecting indigenous developments.

C. Key Military Technologies: Status and Prospects

Computers

54. Soviet computer technology has been limited by fabrication and production technology problems and by difficulties in software development. The most advanced Soviet general-purpose mainframes and minicomputers are at roughly 1972 US levels as far as performance and type are concerned. The lag is considerably greater in terms of the quantity of these machines in use. The Soviets have produced some large-scale scientific computers that offer high levels of performance even by current Western standards, [redacted] Central processor performance typically is at a high level, but memory technology is limited. The Soviets have been slow to rectify their software problems; improvement in this area will require strength in management and customer relations, areas of traditional Soviet weakness.

An antiquated telephone system and the lack of advanced communications software limit Soviet computer networking capabilities.

55. Through 1985, the Soviet military will use the same models of general-purpose computers and minicomputers supplied to civil users, particularly for planning, for command and control applications, and, in some cases, for fire control applications. The military sector also will draw on civil expertise in networking computer systems; both types of users will require off-the-shelf availability of hardware, fully developed software, and an infrastructure that can easily support both. While this trend toward the use of available civil models will grow, the military will continue to have priority and its versions will be subjected to stricter quality control, specialized packaging, and careful component selection—in short, better made. The Soviets will probably not be able to decrease the overall lag of about seven to eight years, relative to the United States, in computer technology. Indeed, Soviet technology limitations in main and auxiliary memory systems and adequate software for operating systems may have an additional slowing effect. The trend for the 1980s will be for the same lag or possibly a somewhat greater one in computer technology relative to the United States.

56. There is an alternative view [9] that, while the US civilian consumer sector will likely quarantee that US basic computer technology will continue to lead that of the Soviet Union by a substantial margin, the effective lag—in terms of technology available for military application—will likely be substantially less in high-priority areas through continued Soviet exploitation of Western and Japanese computer expertise, hardware, software, and production technology. In addition, the Soviet drive to carry new systems through to deployment is expected to cause the tested and deployed computer technology in Soviet military systems to continue to gain relative to that of the United States.

Microelectronics

57. Since about 1965, the Soviets have placed a high priority on microelectronics R&D, and the military clearly oversees the development and production of advanced integrated circuits. The first Soviet military application of small-scale integration (SSI) microelectronic technology occurred in about 1968, and we expect to see military application of large-scale integration (LSI) in the mid-1980s. Some evidence suggests that the Soviets have recently stressed microelectronics production process technology at the expense of design/layout studies. Their typical practice to date has been to copy US devices. Many of their own devices are designed for compatibility with Western parts, and they rely on legally or illegally obtained Western parts to supplement their own base. Despite this, the latest Soviet device design capability is about three years behind that of the United States while the production capability lag is about nine years.

58. Soviet military systems designers are expected to continue to use devices that are pin-for-pin compatible with Western parts, thus decreasing the development time for new systems. Substitution of indigenously produced parts can then be made when they become available. By the early 1980s these procedures will probably enable Soviet electronic systems developers to design and in some cases produce advanced systems in spite of not having domestically produced basic microelectronics technology. Thus, through acquisition of Western components, the Soviets' future military applications of microelectronic technology may be more advanced than their general technology level would suggest.

59. Military and civil systems designers will make increasing use of electronically identical parts. The military devices, however, will receive special packaging and testing, and in some cases will need redesign and modified production processing for radiation hardening to meet military requirements. The Soviets' many problems in supporting technology, including shortages of semiconductor-grade silicon, will probably not be adequately offset by their aggressive technology development and acquisition efforts. In the case of microelectronics, Western technology is now advancing so fast that the production technology gap probably will continue to widen. The general Soviet microelectronics technology lag, relative to the United States, is projected to increase.

60. There is an alternative view [10] that the effective Soviet lag in microelectronics relative to the United States is likely to be substantially less in high-priority

[9] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; and the Director of Intelligence, Headquarters, Marine Corps.*

[10] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; and the Director of Intelligence, Headquarters, Marine Corps.*

[redacted]

areas because of availability of microelectronics hardware and production technology from Japan and the West. Thus, this view holds that microelectronics technology available for use will continue to lag that of the United States by an approximately constant amount. Tested technology is likely to gain on but not pass that of the United States, with deployed technology an unknown because of apparent Soviet choice to use proven technology—apparently for survivability purposes—where the United States generally chooses to use advanced solid state devices.

Signal Processing

61. The Soviets' theoretical understanding of most aspects of signal propagation and signal processing techniques and algorithms, is probably on a par with that of the West. They lag the West by five to 10 years in the speed of digital signal-processing equipment and its production. In many respects their expertise in optical data processing is on par with that in the West, and research in this and related analog equipment such as surface-acoustic-wave (SAW) devices probably will intensify as an alternative to their lagging digital signal processing capability. Operating equipment for some applications of optical data processing of signals could be produced in three to five years. Clutter suppression techniques also lag the West because of slower implementation of digital technology. In some instances, hybrid signal processors that use both digital and optical technologies could also be expected in the 1980s. There is an alternative view [11] that, while the Soviets are apparently behind the United States in digital processing, they have emphasized hybrid processing (potentially at least as fast as digital) over the years and lead the United States in that area. Both processing techniques are applicable to clutter suppression. [redacted] It is, therefore, not clear that the Soviets lag the West in clutter suppression.

62. Soviet advances in signal processing technology in the 1980s will probably include digital processing based on advanced medium-scale integration (MSI) microelectronics technology, digital pulse doppler radar technology, digital image formation, and pattern recognition. For high data rate applications, optical processing could be available somewhat earlier than digital. The slight lag of the USSR relative to the United States in signal processing will probably continue, except perhaps in optical processing, where the Soviets, driven in part by their deficiencies in digital technology, may make some gains relative to the United States.

Production Technology

63. A major weakness in the Soviets' ability to incorporate new technology in military systems lies in their production technology. In particular they generally are not advanced by Western standards in production processes where large quantities of high-technology products are concerned.

64. The Soviets have demonstrated good capability in the fabrication of heavy structures where innovative welding, forging, and extruding techniques have been employed. Titanium processing and fabrication as in the A-class submarine pressure hull is an example. Their industrial production, however, is generally marked by deficiencies in quality control, automation, and mechanization. As a result, Soviet production performance even in high-priority military areas has been uneven. In some cases where advanced processes are crucial to the attainment of military performance objectives, as in the production of optics for a tactical air defense system, and in millimeter-wave components, the Soviets have successfully introduced precision machine technology comparable to the level of US state of the art. Still, in other areas they have been unable to establish and maintain high standards of quality control, as in the production of electronic componentry or the manufacture of a high-bypass turbofan engine.

65. Production sector deficiencies result in part from the Soviet incentive system, which rewards the fulfillment of near-term production targets more than it encourages innovative solutions, and from a shortage of high-precision production machinery (such as numerically controlled machine tools) capable of maintaining precise specifications and tolerances. Such incentives and shortages have contributed to Soviet managers' reluctance to incorporate new technology in areas where technology already in use will satisfy the performance requirement.

66. Defense hardware production technology will continue to be modernized gradually with new domestically produced equipment and continued acquisition

[11] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; and the Director of Intelligence, Headquarters, Marine Corps.*

from the West. It will continue to be characterized in the short run by labor-intensive processing. However, some improvements in productivity and machining accuracy will come from the increased use of automated manufacturing centers and other numerically controlled machine tools. Recent large purchases of machining centers from Japan and Western Europe may have already benefited some military manufacturing sectors, such as the Soviet aircraft industry. The Soviets could probably also increase their production significantly by applying available technology to automation and mechanization of production along with computer-aided design and manufacturing.

67. In some technology areas such as electronics, the Soviets have chosen to copy Western machinery and processes. This allows them to progress faster and at lower cost than if they relied on their own resources. So long as they rely on copying, rather than on indigenous innovation, they will probably remain behind the West in achieving high-yield, high-quality production.

68. There is an alternative view [12] that, while the Soviets will remain behind the United States in many areas of production technology over the near term, the increased availability of domestic and foreign automated production processes, will permit them to gain on the West in improving the efficiency of their production processes. This view also holds that the existing lag may not be militarily meaningful since the current Soviet capability is adequate to support major military requirements.

Communications for Command and Control

69. Command and control communications technology involves the melding of technologies for communications and for computers (for the latter see paragraph 54). Survivability and reliability have been major considerations in Soviet communications systems design; parallel R&D in landline, high-frequency (HF), and very-high-frequency (VHF) communication means, and redundant equipment and routing have been emphasized. The Soviets' present R&D includes extending the frequency range used by communications systems, applying spread-spectrum modulation, and increasing the sophistication of their communications satellite systems. Other Soviet development work is going on in the application of superconducting technology to circuits and antennas, research in propagation and natural noise both in underwater acoustics and in lower frequency radio bands, and application of optical communications. The Soviets in general lag the United States in spread-spectrum and high-information-rate systems, high-speed signal processing, and fiber-optics-communications technology.

70. The Soviets' progress in command and control communications in the 1980s is expected to profit from their efforts in communications theory and propagation and to be moderated by their general problems with computer technology. They will certainly make more use of synchronous communications satellites for communicating with forces at all echelons. They will probably move higher in the frequency spectrum to take advantage of the increased bandwidths available there, and may make wider use of spread-spectrum techniques because of their greater immunity to jamming and potential for increased covertness. The Soviets will also probably increase the use of low-probability-of-intercept, short-duration-signal design techniques. Computers and the associated software will, of course, continue to be developed for communications purposes. On balance the Soviet lag in communications technology for command and control is expected to remain unchanged.

71. There is an alternative view [13] in the Intelligence Community that, while the Soviets lag in microwave and satellite communications technology, they are on a par with the United States in other basic areas of military communications technology and that they lead the United States and are expected to increase the lead in tested and deployed high-frequency and sub-HF communication technology. Distinct advantages are held by the Soviets at all frequencies in terms of quality of deployed equipment and in link and node-to-node redundancy. This view holds that as Soviet microwave and satellite communication technology and the associated signal processing technology matures, the US lead in basic and available communications technology will diminish.

Directed Energy

72. The Soviets' capability to develop large lasers is roughly equivalent to that of the United States. They

[12] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; the Director of Naval Intelligence, Department of the Navy; and the Director of Intelligence, Headquarters, Marine Corps.*

[13] *The holders of this view are the Director, Defense Intelligence Agency; the Assistant Chief of Staff for Intelligence, Department of the Army; and the Director of Intelligence, Headquarters, Marine Corps.*

[redacted]

have done high-quality work on all types of lasers known to be scalable to high output powers. Their highest power achievements probably are with carbon monoxide and carbon dioxide electric discharge lasers (EDLs), which have been built both in continuous wave (CW) and pulsed modes, with outputs probably in the megawatt (MW) range. The Soviets probably could build megawatt-class GDLs if they chose to do so. They also have constructed large long-pulse (millisecond duration) glass lasers for unknown purposes in military projects and are pursuing, reportedly for terminal ballistic missile defense, explosively driven iodine lasers; these programs have had no US counterpart. Excimer lasers are in an early developmental stage in both the USSR and the United States. We believe the Soviets could have an excimer laser of several hundred kilowatts by the late 1980s.

73. We believe that in the technology areas of chemical and excimer lasers, the USSR is comparable to the United States. While the Soviets may lag in CW chemical lasers, their work in pulsed chemical devices is comparable to and in some cases ahead of US work. In the excimer area, the Soviets are in the forefront of the electron beam device technology required to pump such lasers. There is an alternate view [14] that Soviet work on chemical lasers for weapons use probably is a few years behind that of the United States.

74. Soviet laser window and mirror fabrication capability lags that of the United States. The Soviets depend to some extent on US metal foils for separating electron guns from the laser cavity in e-beam lasers. They probably are roughly on a par with the United States in wavefront correction techniques; they probably lag in acquisition/tracking/pointing; they appear to have a lead in development of some suitable power sources. They may have now the capability to build a space-based acquisition/tracking/pointing subsystem for high-energy lasers with a final performance (including jitter), of 10 to 15 microradians, but we have no evidence that they are actually developing subsystems. We believe they could build such subsystems with a capability of approximately 5 microradians by the late 1980s. There is an alternative view [15] that the Soviets may build a space-based acquisition/tracking/pointing system for high-energy lasers with a final performance on the order of 0.5 microradian by the late 1980s and thus Soviet weapons could have a tenfold increase in energy density relative to a 5-microradian beam at the same range or, alternatively, a threefold increase in range for the same output power. Such increased performance would be quite significant.

75. [ ] the Soviets probably have undertaken research designed to investigate PBW feasibility. There is an alternate view that, [ ] the program is probably in basic R&D which will result in a demonstration of propagation of a particle beam to militarily significant ranges; however, [ ] leave open the possibility that the Soviets are further advanced. They may be in at least applied R&D culminating in feasibility demonstration for some applications of PBWs.[16] They are far from resolving the technical problems (propagation, power conditioning, accelerators, beam-aiming magnets) that must be solved to develop an operable weapon, even if the PBW concept is feasible. In the radiofrequency (RF) damage (nonnuclear electromagnetic pulse) weapon area the Soviets are able to build suitable power sources and antennas, and they have developed microwave generators of very high peak power.

76. We expect that the Soviet status relative to the US in all aspects of laser systems will remain roughly the same into the 1980s. The Soviets could build RF damage weapons by the mid-1980s, but there is no substantial evidence of any activity to do so. The Soviets' rough equivalence with the United States in those technologies that will determine the feasibility of PBWs is expected to continue.

Guidance and Navigation

77. During the last year the Soviets have introduced into their deployed force some missiles that have been specifically modified for improved guidance system performance. [ ] This indicates that the Soviets have made strides in the use of higher precision machinery and instruments in their production lines. The acquisition and applica-

[14] *The holder of this view is the Director, Central Intelligence Agency.*

[15] *The holder of this view is the Director, Defense Intelligence Agency.*

[16] *The holder of this view is the Assistant Chief of Staff, Intelligence, Department of the Air Force.*

[redacted]

tion of Western-made equipment may have contributed to these recent improvements.

78. Improvements in calibration and in error modeling will further reduce guidance measurement errors of the Soviets' conventional gyroscopes and accelerometers. Within the next decade they also may begin making selected use of electrostatic gyros and laser gyros in place of conventional gyros. They have developed correlation sensors equivalent to some operational US varieties. [redacted] They now have adequate technology to support a global positioning satellite system. Although they use navigation techniques more extensively in their land combat vehicles than does the United States, they are behind in manpack navigation and land inertial navigation technologies.

Power Sources

79. Extensive Soviet R&D efforts on a wide range of power generation and conditioning technologies extend from improvement programs on conventional power equipment—batteries, solar cells, rotating machinery, nuclear reactors, transformers—to major R&D programs on advanced areas with high development risk—nuclear direct conversion, magnetohydrodynamic (MHD) and magnetocumulative generators (MCG), pulse power conditioning, fusion research. The Soviets' work in nuclear power sources has high priority and is advanced. They lead the United States in some power source and conditioning technology applicable to directed energy. They lead in nuclear reactors for space power, but lag in radioisotope thermoelectric generators for space power.

80. Continuous wave (CW) and low-pulse-rate electrical power supplies suitable for airborne applications at average power levels up to tens of megawatts or for space applications to several megawatts will be available to the Soviets by the early 1980s. Higher pulse rates at peak pulse powers much above 1 gigawatt will be difficult to achieve, but a number of technologies are leading in this direction. They should be able to develop a 15-kilowatt (electric) nuclear power supply with a three-year operational lifetime by 1990; and a 50-kilowatt (electric) nuclear power supply with a five-year lifetime in the 1990s. The Soviets appear to perceive a very wide range of military/aerospace power requirements and are pursuing a number of alternative approaches for each type of requirement.

Structural Materials

81. In metallic materials the Soviets achieved a rough parity with the United States by the late 1970s. Their steels, aluminum, magnesium, and titanium alloys and nickel-based superalloys are comparable to those used in the West. A major effort to exploit the potential of titanium has given the USSR world leadership in the quantity of titanium produced, in research on high-temperature titanium metallurgy, and in some titanium fabrication techniques, especially extrusion. The Soviets' welding, forging, and casting technologies are outstanding, as is their innovative work on electroslag and plasma-arc refining methods, electroslag casting, and thermomechanical processing. Soviet researchers are making substantial progress to close the gaps in fracture mechanics and powder metallurgy. They have a large program to develop metal-matrix composites.

82. In the area of nonmetallic structural materials, Soviet scientists have achieved comparability with the West in their technical understanding of the behavior of materials, but deficiencies in plant and equipment, especially in the chemical industry, have hampered the Soviet Union's ability to apply certain types of high-performance synthetic polymeric materials, glasses, ceramics, and the newer advanced composites. The Soviets have bought production facilities from the West to hasten the expanded production of the more important high-temperature resins, fibers, ceramics, and composites. Soviet scientists have announced development and limited application of organic-matrix (for example, graphite-fiber-reinforced epoxy) composites to secondary structures of military and civil aircraft, in a program that appears to be roughly five years behind the US equivalent.

83. In the area of armor, the Soviets have brought their R&D talent in materials technology to bear on increasing the protection of ground combat vehicles against kinetic energy and chemical energy antiarmor munitions. The use of electroslag refined steel plate is suspected to be responsible for the improved quality of the armor noted in Soviet combat vehicles fielded in the early 1970s. Laminated armor concepts have been employed in the frontal arc of both the T-64 and T-72 medium tanks. The use of antiradiation liners provides increased protection. The Soviets have made concerted efforts to develop laminated materials

and advanced composites, and they are probably investigating armor concepts employing spatial arrays.

84. The USSR's strong R&D effort in the areas of materials processing and fabrication is expected to continue and show a steady commitment of resources through the 1980s. The Soviets' weapons are expected to benefit from their advances in metallic material, but their metal matrix work is unlikely to have any significant impact before the late 1980s. We expect to see an increased use of composites, especially aerospace structures. In the mid-to-late 1980s, the already high level of armor protection for Soviet combat vehicles is expected to profit from the USSR's large, diverse materials programs. The Soviets are expected to maintain a considerable lead in fabrication technology for thick titanium plate—for example, in submarine hull fabrication—through the 1980s.

Propulsion

85. The Soviets have a good capability in air-breathing aerospace propulsion technologies, although they lag the United States in high-thrust (particularly high-bypass-ratio) applications in subsonic aircraft. Their current work in air-breathing aerospace propulsion is aimed at high-temperature operation of turbine-based systems through advances in materials, cooling, and surface coating and manufacturing processes. The Soviets also have substantial R&D under way in ram effect (ramjet/scramjet) engines, and their fuel injector, flameholder, inlet, and nozzle techniques and combustion studies for these engines are advanced. There also is considerable activity in combined cycle concepts, where they have developed advanced ejector designs.

86. In rocket propulsion technologies the Soviets' closed loop engines and some of their thrust chamber manufacturing concepts are superior to those of the United States. They have attained very high mass fractions (ratio of fuel weight to total weight) in some of their large military liquid-propellant rockets, have investigated all nozzle concepts employed in the United States, and have done comprehensive propellant research. They have major programs covering all aspects of solid-rocket propulsion, and future advances in this area are expected to be rapid.

87. The Soviets have a continuing program devoted to the development of high-powered propulsion systems for their nuclear submarines. They have developed liquid-metal-cooled reactors and possibly even a direct-cycle system as alternatives to the more common pressurized water reactors for submarines. The Soviet A-class submarine has [redacted] speeds in excess of 40 knots and has a propulsion plant with a horsepower/ton ratio (nuclear horsepower per ton of propulsion plant) probably significantly greater than those of US nuclear-powered attack submarines.

88. The Soviets' lead in storable liquid-rocket propulsion for missiles will continue into the 1980s. Serious combustion instability problems that they have encountered in the design of large-thrust closed-loop engines (greater than 1 million pounds of thrust, for example, for space booster use) may hinder further development of this technology, even though a major Soviet effort to understand and solve these problems continues. The Soviets' solid-propellant propulsion technology is about five years behind that of the United States; however, the gap is closing. They may be catching up in areas of materials technology directly related to propulsion such as fiber-reinforced materials for motor cases and nozzles. Their lead in horsepower/ton ratio demonstrated in the A-class submarines will probably continue through the 1980s.

Nuclear Weapons and Chemical Explosives

89. [redacted] the newly built nuclear power reactor fuel reprocessing plant at Kyshtym and the Soviets' advanced isotope separation efforts (especially laser isotope separation) could aid them in separating the transplutonic isotopes. Lastly, the acquisition of Western precision machining equipment would facilitate the fabrication of complex-shape warhead components.

90. The Soviets have a lead of four to six years over the United States in chemical explosives research and, in view of their considerably greater manpower devoted to this topic, probably will increase that lead in the 1980s. Specific areas of lead are in hydrogen-free (smokeless) propellants, inorganic explosives, nitrocellulose enclosed particles of aluminum, and fuel-air explosives. They lag the United States in the area of insensitive explosives and HMX production, probably because of a lack of interest.

Sensors

91. There is extensive Soviet R&D on both acoustic and nonacoustic sensors for antisubmarine warfare. Improved active sonars based on new, powerful low-frequency sound sources could be deployed in ASW systems in the next decade or so. Although Soviet research in towed acoustic arrays is about eight years behind that of the United States, no sensor technology breakthroughs are required and this research could lead to improved operational ASW systems in the mid-to-late 1980s.

92. The Soviets are also engaged in extensive R&D of nonacoustic ASW systems [ ]

93. The Soviets lead the United States in some applications of radar sensor technology—that is, over-the-horizon back-scatter radar and real aperture space-based radar. They also lead in millimeter wave tube technology and are comparable in microwave tubes and components.

94. The Soviets' past high-priority attention to some areas of ASW and radar sensor technology application is expected to continue. They could develop space-based radars for detection of large aircraft, such as those capable of carrying cruise missiles, by the late 1980s, and smaller aircraft in the 1990s. Their lead in millimeter-wave technology will probably continue. Active sonars and towed acoustic arrays for detections beyond the first convergence zone (30 nautical miles) will probably become operational in the 1990s. An alternative view is that the Soviets will not have developed operational passive-towed-array sonar systems with consistent or reliable detection ranges in excess of 30 nautical miles (that is, approximately one convergence zone) against either current or future US submarines by the year 2000.[17] Operational microwave radar and infrared radiometry systems for ASW may be a possibility for the 1990s—if proved feasible. The Soviets will remain roughly on a par in radar technology with the United States into the 1980s and will probably make some gains in acoustic ASW and electro-optical sensors. We expect them to make advances in nonacoustic ASW sensor technology but cannot project their standing relative to the United States.

95. In electro-optic sensor technology, the Soviets have the necessary competence to support production (at least in limited quantities) of high-quality devices, including charge-coupled devices (CCDs). They have fabricated such detectors from visible through long wavelength infrared in linear scanning arrays and matrix mosaic staring sensor formats. Visible spectrum detector arrays consisting of up to 40,000 elements have been produced. They probably could develop by the mid-1980s an Earth-imaging camera based on CCD technology having about a 1-foot resolution capability from an altitude of about 185 kilometers, but an operational system would not be available until the 1990s.

96. The Soviets have a capability to design and produce quality optical systems. Soviet high-sensitivity and moderate-sensitivity black and white aerial films are about equal in image quality to those produced in the United States; however, we have not identified any Soviet film that approaches the best US high-resolution film. It is estimated that the Soviets can achieve an optic mirror size for space up to a limit of approximately 5 meters for single mirrors in the late 1980s. They may also be able to achieve, for smaller mirrors, a surface control accuracy, using adaptive optics, of about 1/40 wavelength over the same period.

IV. MILITARY SYSTEMS PROJECTIONS FOR THE 1990s

97. This NIE makes projections for a series of military systems that may reach initial operational capability (IOC) in the 1990s. The projections are in areas where new Soviet systems performance could have significant impact on what we believe to be critical Soviet requirements or deficiencies. Early R&D programs, known or estimated Soviet system performance trends, and the availability of relevant key technologies serve as the basis for making a projection. For each new system projected, significant attributes, performance, or mission capability are established to the extent possible, and the key relevant technologies

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[17] *The holder of this view is the Director of Naval Intelligence, Department of the Navy.*

are identified. The projections do not deal with effectiveness of individual systems or with systems reaching IOC in the 1980s and contributing to total Soviet military capability in the 1990s.

98. New systems performance projected for the 1990s depends on when required key technology levels become available and when in the R&D cycle the Soviets freeze the incorporation of available technology into systems design. The incorporation of technology differs for the two major themes—evolutionary and advanced concepts—in Soviet R&D. Soviet practice in evolutionary R&D is to incorporate already proven technology into systems designs, with the design freeze on technology occurring some two to three years into the six-to-12-year R&D cycle for evolutionary systems. Thus, for evolutionary R&D there is a lag of roughly five to 10 years between the selection of proven technology and its appearance in deployed systems. R&D in advanced concept systems is tied directly to the development of new technology or the successful use of unproven technology. R&D times for these systems will vary considerably, depending on the successful development and application of new technologies to meet program goals. Soviet technology advances in the 1980s and, in some cases, the 1990s will be available for use in new 1990s systems.

99. Current Soviet R&D activity includes a number of significant programs—in ICBMs and aircraft, for example—that fit the fundamental evolutionary theme in Soviet R&D. We are able to project IOC for these systems in the 1990s on the basis of our understanding of typical Soviet R&D cycles. Current Soviet R&D activity also includes a number of programs that are investigating advanced technological concepts. We are able to project certain of these R&D programs—where concept feasibility is not involved—into military systems for the 1990s on the basis of prospective advances in key technologies, as in some areas of ASW. But we cannot project the final outcome of Soviet R&D efforts where technological solutions are unknown to the United States and probably to the Soviets as well. We expect some increased emphasis on advanced concepts in Soviet R&D. The USSR may be able to develop significant new concepts based on the steady advances which we now foresee in specific technologies.

100. There are many uncertainties affecting our projections of systems types and performance characteristics. Whenever possible we base our projections of 1990s weapon IOCs on evidence of development that has already begun. Even when this evidence is available, the very early status of these R&D programs and the major decision points that they must successfully pass adds to our uncertainty. We are also unsure of the role that Soviet resource expenditures for military R&D will play in these R&D decisions.

101. The primary basis for projecting 1990s Soviet systems performance is Soviet capability in the key technologies projected for the 1980s. We are often uncertain, however, of Soviet plans to use available technology for specific systems or concepts. Improved system performance is not necessarily dependent on the availability of a specific technology. Novel application of less advanced technology can often enhance weapons performance and military capability as much as new technology. The Soviets have been innovative in the past in the use of technology already available to them. Different design approaches or philosophies (stressing quantity over quality, for example) have compensated for technological shortcomings in some past Soviet R&D. Our uncertainty in this area could affect the validity of our judgments of projected new performance.

102. A large source of uncertainty in our projections lies in the use of past trends. Trends in Soviet system performance—the second part of our evidential basis for projection of performance—can easily change. Further, the relationship between past trends and specific weapons in early R&D is often unclear.

103. In view of our uncertainty, the new systems and performance projections summarized in tables 6A, 6B, and 6C should be viewed as representative. Projections are made at three different levels, depending on our judgment of the probability of occurrence of the new system and performance in the 1990s:

— A high probability of occurrence projection is one we view as having significantly better than an even chance of taking place. [ ]

— A medium probability of occurrence projection is one we view as having a roughly even chance of occurrence. [ ]

— A low probability of occurrence projection is one we view as having significantly less than an even chance of occurrence.

104. We also have evidence of Soviet activity related to other advanced concepts These activities conceivably could produce significant military results in such areas as:

— ABM concepts based on high-energy lasers or even particle beams.

— Weather and climate modification.

— Biological effects of nonionizing electromagnetic radiation.

— Communications through ionospheric, magnetospheric, lithospheric, or even paraphysical effects.

— Laser propulsion.

— Hypersonic cruise vehicles.

[redacted]

Table 6A

Selected Soviet Military Systems Projected for IOC in the 1990s
(High Probability of Occurrence)

System/Concept	Soviet Requirement or Deficiency	Potential New Performance	Key Technology		IOC
STRATEGIC OFFENSIVE SYSTEMS					
Large ICBM (6th generation, SS-18 class)	Fractionation, MX response	Around 30 RVs with accuracy (CEP) of about 140 meters	Materials; guidance		Late 1980s-early 1990s
ICBM (6th generation, solid propellant) [b]	Survivability [b]	Reliability, mobility [b]	Propulsion, guidance		Early 1990s
Backfire follow-on	Penetration, survivability	Better low-altitude penetration; higher speed and longer range	Materials; microelectronics		1990s
New weapon system for Typhoon ballistic missile submarine	Survivability, readiness accuracy	Accuracy (CEP) of 500-600 meters	Guidance, computers		Late 1980s-early 1990s
STRATEGIC DEFENSIVE SYSTEMS					
Improved air superiority aircraft	Low-altitude air defense/air superiority; high maneuverability	Advanced lookdown/shootdown; possibly control configured	Microelectronics, signal processing, sensors, computers		1990s
Advanced command and control communications for strategic air defense (widespread general deployment)	Coordinated air defense	Improved netting for ground-controlled intercept (GCI), increased capability in low-altitude defense	Computers (software for netting), communications		Early 1990s
GENERAL PURPOSE FORCE SYSTEMS (GROUND)					
Modernized theater command and control communications (widespread deployment)	Battlefield management	Versatile and survivable equipment; automated control system	Microelectronics, computers (software for netting), production, communications		Early 1990s
T-80 tank follow-on	Mobility, survivability	Improved day/night, cross-country mobility, armor protection	Sensors, materials (armor)		Late 1980s-early 1990s

[redacted]

BMP infantry fighting vehicle follow-on	Mobility, survivability	Improved day/night, cross-country mobility, armor protection	Sensors, materials (armor)	1990s
Improved self-propelled artillery	Firepower, mobility	Improved lethality and higher rate of fire	Microelectronics	1990s
Improved helicopter gunship	Maneuverability, firepower	All-weather, higher speed, air-to-air	Sensors	1990s
GENERAL PURPOSE FORCE SYSTEMS (AIR)				
Large transport (AN-22 follow-on) [d]	Logistics	Heavy, outsize cargo	Propulsion	Late 1980s-early 1990s [d]
GENERAL PURPOSE FORCE SYSTEMS (NAVAL)				
New class of attack submarine	ASW, anti-SLOC [e]	High speed, great depth, quietness	Production, materials, propulsion	Early 1990s
Attack aircraft carrier	Overseas power projections, anti-SLOC	Fleet air defense, air superiority for fleet and control areas, ground support	Production	Late 1980s-early 1990s
Improved air cushion vehicles	Survivability, amphibious assault, weapons platform	Speed, size	Materials, propulsion	1990s
SPACE				
Advanced space station (permanently manned)	Intelligence	Continuously manned multimission	Sensors, signal processing	Late 1980s-early 1990s
Large space shuttle [f]	Reusable space transport for large payloads	Large lift and volume	Materials, propulsion	Early 1990s

b We believe the Soviets will continue to do R&D which will afford them the option to deploy a mobile solid-propellant ICBM in the 1990s. Accuracy (guidance and control—G&C—technology) may also be a requirement under the mobility option.
c We are uncertain whether these systems will find first application in strategic defense or general purpose force missions.
d *DIA and Air Force believe that the AN-22 follow-on will reach IOC in the mid-to-late 1980s.*
e ASW = antisubmarine warfare; SLOC = sea lines of communication.
f *DIA and Air Force project the large space shuttle with medium rather than high probability.*

Table 6B

Selected Soviet Military Systems Projected for IOC in the 1990s
(Medium Probability of Occurrence)

System/Concept	Soviet Requirement or Deficiency	Potential New Performance	Key Technology	IOC
STRATEGIC OFFENSIVE SYSTEMS				
New SSBN/SLBM system	Survivability, readiness, accuracy	Quietness, 250-500 meters CEP	Computers, materials, guidance/navigation	Early-to-middle 1990s
New SLBM	Possible response to MX	Missile CEP of 200 meters	Guidance, computers	Early-to-middle 1990s
STRATEGIC DEFENSIVE SYSTEMS				
New SAM (SA-X-10 follow-on)	Low-altitude air defense	Improved capability in low-altitude defense	Sensors, signal processing, propulsion	1990s
New SAM (SA-5 follow-on)	Medium- and high-altitude defense	Improved capability in medium- and high-altitude defense	Sensors, propulsion, signal processing	1990s
Space-based laser ASAT	ASAT (antisatellite system)	Multiple-target capability	Directed energy (including pointing and tracking), power soures	Early 1990s
Improved Moscow ABM system [b]	Improved layered defense for light attack	RV discrimination, improved target-handling capability	Computers, signal processing	1990s
GENERAL PURPOSE FORCE SYSTEMS (GROUND)				
Tactical SAM (SA-11 follow-on)	Targeting flexibility, low-altitude defense	Improved multiple-target/low-altitude capability	Sensors, signal processing, propulsion	Early-to-middle 1990s
Improved SRBMs	Targeting flexibility	Improved warheads, range, accuracy	Microelectronics, G&C, sensors computers, propulsion	Mid-to-late 1990s

Improved ground-based laser (for air defense)	Firepower	Multiple-target capability, long range	Power sources, directed energy	1990s
GENERAL PURPOSE FORCE SYSTEM (AIR)				
STOL theater transport (AN-72 follow-on)	Theater logistics	STOL (short takeoff and landing)	Propulsion	1990s
Ground attack aircraft	Firepower for ground support	Night/all-weather enhanced navigation	Microelectronics, sensors	Early-to-middle 1990s
GENERAL PURPOSE FORCE SYSTEMS (NAVAL)				
Towed arrays (long range)	ASW	90 nm detection range [c]	Signal processing	Mid-1990s
Global ELF communications	Real time communication, submarine invulnerability	Communications with deeply submerged submarines	Power sources, microelectronics	1990s
New cruiser	Power projection	Endurance, sustained speed	Propulsion	Late 1980s-1990s
Large hydrofoils, 300 tons	Antishipping, ASW	Speed	Materials, propulsion	Early 1990s
Wing-in-ground and surface effects vehicles	ASW (some aspects), amphibious assault, coastal patrol	Speed	Materials, propulsion	1990s
Improved cruise missiles	Anti-SLOC, anti-combatant	Improved over-the-horizon capability	Sensors, microelectronics	Early-to-middle 1990s
Improved V/STOL	ASW, attack, close air support	Night/all-weather range, speed	Microelectronics, sensors, propulsion	Mid-1990s
Improved carrier-based takeoff and landing (CTOL)	Close air support, air defense, attack	Increased range, lookdown/shootdown	Microelectronics, sensors, propulsion	Early-to-middle 1990s

[b] interceptors may appear in the Moscow ABM system in the mid-to-late 1980s.

[c] *See paragraph 94 for an alternative view of the Director of Naval Intelligence, Department of the Navy.*

Table 6C

Selected Soviet Military Systems Projected for IOC in the 1990s
(Low Probability of Occurrence)

System/Concept	Soviet Requirement or Deficiency	Potential New Performance	Key Technology		IOC
STRATEGIC OFFENSIVE SYSTEMS					
Maneuverable RV (tactical SRBM or mobile ICBM)	Accuracy	50 meters CEP accuracy, or accuracy with mobility	Microelectronics, G&C, sensors, computers		1990s
Strategic bomber (follow-on to B-1 type)	Strategic flexibility	Low-altitude, high-speed, all-weather	Propulsion, microelectronics		1990s
Medium-range ASM or long-range AAM	Standoff weapons or weapons against cruise missile carriers or airborne warning systems (AWACS) [b]	Greater range	Propulsion, microelectronics		1990s
STRATEGIC DEFENSIVE SYSTEMS					
Hard site ABM [c]	ICBM site survivability	Defense against light attack	Propulsion, signal processing		1990s
GENERAL PURPOSE FORCE SYSTEM (GROUND)					
Nonnuclear electromagnetic pulse (EMP) weapon (mobile)	Firepower	Mobility	Power sources, directed energy		1990s
Enhanced neutron warheads (for artillery rounds)	Firepower	Broad-area antitank weapon involving limited collateral damage	Production		Early 1990s

GENERAL PURPOSE FORCE SYSTEM (NAVAL)					
Air- and space-based submarine wake detectors (feasibility has not been established for these concepts)	Broad-ocean ASW	Broad-area search (if concept feasible)	Signal processing, sensors		1990s
Sonar, active, low frequency	ASW	Detection range greater than 30 nm	Sensors, signal processing		1990s

[b] We are uncertain whether this system will find application in strategic offense or general purpose force missions.
[c] We do not make a judgment as to Soviet intent to deploy such a system in contravention of any existing treaties.

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